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H. B. WALKER, President RAYMOND OLNEY, Secretary-Treasurer

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The Object and Scope of A. S. A. E. Activities

THE American Society of Agricultural Engineers was organized in December, 1907, at the University of Wisconsin by a group of instructors in agricultural engineering from several state agricultural colleges, who felt the need of an organization for the exchange of ideas and otherwise to promote the advancement of agricultural engineering. The object of the Society, as defined by the Constitution, is "to promote the art and science of engineering as applied to agriculture, the principal means of which shall be the holding of meetings for the presentation and discussion of professional papers and social intercourse, and the general dissemination of information by the publication and distribution of its papers, discussions, etc."

The membership of the Society represents all phases of agricultural engineering, including the educational, professional, industrial, and commercial fields.

The scope of the Society's activities embraces both the technical and economic phases of the application of engineering to agriculture, and is comprehended in the following general headings:

(a) Farm Power and Operating Equipment—power, implements, machines, and related equipment.
(b) Farm Structures—buildings and other structures and related equipment.
(c) Farm Sanitation—water supply; sewage disposal; lighting, heating, and ventilating of farm buildings, and related equipment.
(d) Land Reclamation—drainage, irrigation, land clearing, etc., and related structures and equipment.
(e) Educational—teaching, extension, and research methods, etc., employed in the agricultural engineering field.

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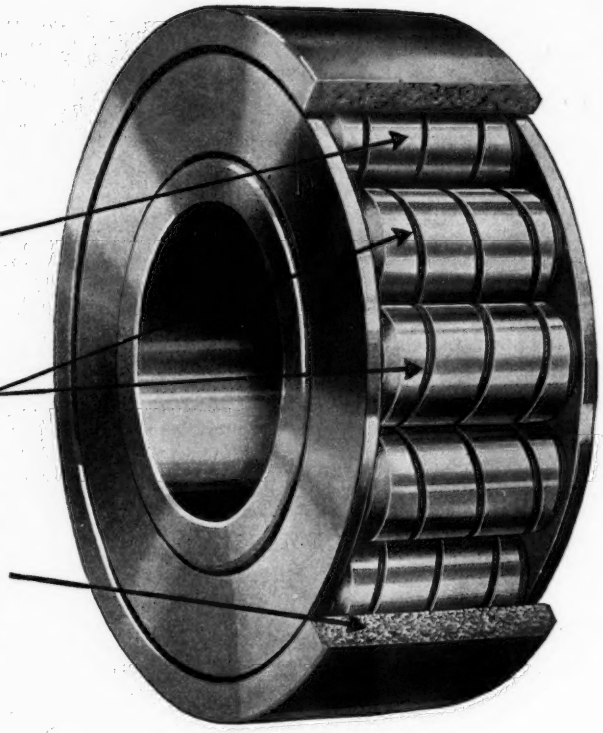

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AGRICULTURAL ENGINEERING

The Journal of Engineering as Applied to Agriculture

RAYMOND OLNEY, Editor

Vol. 6 JUNE, 1925 No. 6

EDITORIALS

Reduce Unit Costs

THE individual farmer has more control over his unit costs of production than over any other factor involved in determining his profits. In the reduction of these unit costs lies his greatest opportunity to increase his profits quickly and dependably.

No matter what the selling price may be, the man with lower unit costs has the greater assurance of making a profit in seasons of low price. He also makes the wider margin of profit in seasons of high price. Furthermore, he has the greater assurance of weathering the storms of farm depression.

The best illustration of this basic fact that I know is found in the records of the Cerro Gordo County (Iowa) corn contest. Out of the 181 five-acre fields checked in 1923, eight obtained yields of over 80 bushels ,and eight got less than 40 bushels per acre. Out of 358 fields checked in 1924, twelve obtained yields of over 60 bushels while eight got less than 20 bushels per acre.

Both years the acre cost of the high yielding fields was but little more than for the low yielders. So, in 1923, the unit or bushel cost for those getting 80 bushels or more was only one-half—or less—that of those getting 40 bushels or less. In 1924 the bushel cost of the crops above 60 bushels was only one third—or less—that of the yields below twenty bushels. In 1924 the extreme was 72 and 13 bushels per acre, so one man's bushel cost was almost six times that of the other.

Even with the comparatively low corn prices of 1923, the men with low unit costs made an attractive unit and acre profit. With the much higher corn prices in 1924, the men with low unit costs made a still larger unit profit and even a larger acre profit, in spite of the lower general level of yields.

The big problem is to increase both unit and acre profits; to increase acre yields at the same time unit costs are lowered. Another way of putting this problem is to increase production for each hour, month, or year of human labor without increasing correspondingly the overhead costs made up of charges for fixed capital, for seed, fertilizer and implements.

This is a man sized job. But the extent to which we solve it will regulate the future improvement of America's agriculture, and even of the entire nation. Its solution will enable us to feed America from the labor of fewer farm workers for each thousand of our population. Its solution will enable still more men to work at producing still more economic and social wealth to be exchanged for the products of these fewer farm workers.

J. A. KING

More Than a Clearing House

WHILE the American Society of Agricultural Engineers has been aptly called a clearing house for ideas in engineering as it pertains to agriculture, and while it is serving an excellent purpose along that line, there is a bigger and better thing that our society is doing.

Founded, as it was, largely by men in the teaching profession it was not at all strange that for some time our society remained pretty much an association of men who looked at things from the academic point of view.

The biggest thing we have done in recent years has been our branching out and taking in men from the various industries which are so closely allied with the work which we are trying to do.

There was a time when the man in the industrial field was looked upon with suspicion by the college man. He, of the industrial field, was always suspected of attempting to use the college and experiment station as a means for exploiting something for personal gain. But we don't find that situation existing today.

Our membership numbers as many or more men from the various agricultural engineering industries as from the colleges. Our clearing house for the exchange of ideas has become more than a clearing house. It has become a melting pot where we have come to know each other, and in knowing each other we have come to find a great deal of good in those upon whom we looked with suspicion before. No longer do we find the teacher looking with suspicion upon the manufacturer's representative. No longer do we find that representative looking upon the professor as a man of theory, an idealist. Each has found that the other can be of tremendous service to our common cause.

When the college man numbers among his associates some of the practical men in the industrial field, and when these men get some of the theory for which the college man has been noted, and sometimes made to suffer, both parties to the transaction become better balanced. They appreciate each other's problems. They are able to work in harmony for the good of one of the finest professions of today—agricultural engineering.

FRANK A. MECKEL

Economics and Engineering

EVERY agricultural engineer is interested in anything that contributes to a greater appreciation on the part of the public of what agricultural engineering really means and how it contributes to the development of agriculture as an industry and the raising of the standard of living on the farm. Especially in this connection the agricultural engineer should miss no opportunity to educate those with whom he comes in contact or by whom his influence is felt, that engineering and economics are inseparable; in fact, that engineering is a form of economics and that whereas civil engineering for example deals with the economics of design and construction of engineering works, agricultural engineering should deal more particularly with the economics of agricultural development. The following comments by a member of the American Society of Agricultural Engineers is very much to the point and gives agricultural engineers food for thought and action:

"I think it advisable to make it plain that sound engineering and sound economics go hand in hand and that a lot of the so-called economics we are confronted with would not stand the light of engineering scrutiny. We are being overrun now with efficiency engineers and economic engineers. A recent investigation revealed the fact that a majority of these men were trained in accountancy and bookkeeping. 'The Engineering News-Record' calls them 'adders and counters'. If ever a term was abused it is the term 'economics'. I believe we ought to make it plain that sound engineering produces desired results with an optimum of economy."

Some Fundamentals of Plow Design *

By Theo Brown

Mem. A. S. A. E. Manager, Experimental Department, Deere and Company

THE plow is the oldest known agricultural implement, and the development of agriculture and, coincident with it, civilization has followed very closely in the wake of the development of the plow. Primitive man used his hands to make the first seedbed and to plant the first seeds. He learned his lesson from the ant and the squirrel. But, ingenuity born in him, developing as time went on, prompted him to search for things that would increase his efficiency. He ceased to use his hands to loosen and pulverize the soil, when he had devised a stick sharpened at one end to loosen the earth, and blunted at the other to pulverize lumps. That was the first plow, and from it man has painstakingly and slowly evolved the modern plow.

Down through the centuries this development of the plow has come slowly, a little added here and a little there. And many men long since forgotten have contributed their share towards creating a better plow.

During the last century, however, there was more progress than in all time before, and it is to such men as Wiard, Oliver and Deere that the perfected design of the present plow is largely to be credited.

The point that I am anxious to make clear is the fact that the plow as we know it today is the result of a development that has lasted through many ages of endless trials and experiments. The chaff has been discarded; the wheat kept.

And so, with such a background, it will be seen that there must be certain essentials in plow design that have to be considered as fundamentals and so accepted. In this discussion I will simply try to point out some of the fundamentals which the designer is practically forced to treat as such, and then have something to say about the variables in the solving of which the designer may show his originality and ingenuity.

As, without doubt, all present are familiar with the different kinds of plows and also are acquainted with the various elements, bottoms, beams, etc., which are the component parts of a plow, I shall not make any enumeration of either, but will proceed at once to a consideration of the items to which the designer must give his attention.

To start with, since the objective in plowing is the tillage of the soil and the preparation of a seedbed, it may be said that the bottom is the vital, business member of the plow. The balance of the structure is there to make the bottom run correctly. And so my discussion will start with a consideration of the plow bottom.

The working surface of the present day plow bottom is what is known to mathematicians as a warped surface or a surface of revolution. As indicated above, this shape is the result of many centuries of experimentation in which theoretical considerations have had no part.

Many attempts have been made to design a plow bottom surface which would be geometrically correct, the desired end being, of course, to get a surface which would turn the soil and leave it in the best condition for plant nurture and growth. There are no records of any of these attempts having been made until the latter part of the 18th century, and there have been none which have been, to any marked degree, successful. These attempts have been continued until the present time, but the plow bottom surface which we have today is a monument to the efficacy of the age old method of trial and error.

It is of interest and perhaps a matter of surprise to note that among the earliest recorded attempts was one made by no less a person than Thomas Jefferson. The record does not show, however, just how successful his effort was, although a comparison of the equation of his surface with that of a satisfactory present day surface would indicate that he was considerably wide of the mark.

In a treatise, entitled "A Study of the Plow Bottom and Its Action on the Furrow Slice"*, by Dr. E. A. White, the history of these efforts is given and also the equations of the various surfaces experimented with.

There is in this treatise, too, the development of an equation for the surface of the plow bottom of today, and it is shown that most of the successful modern plow bottom surfaces designed by cut-and-try methods have equations which approximate that of a hyperboloid of one sheet.

*Paper presented at the meeting of the Farm Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 3, 1924.

*A. S. A. E. Trans., Vol. 12 (1918), pp. 42-50; U. S. D. A. Jour. of Agr. Research, 12 (1918), No. 4, pp. 149-182.

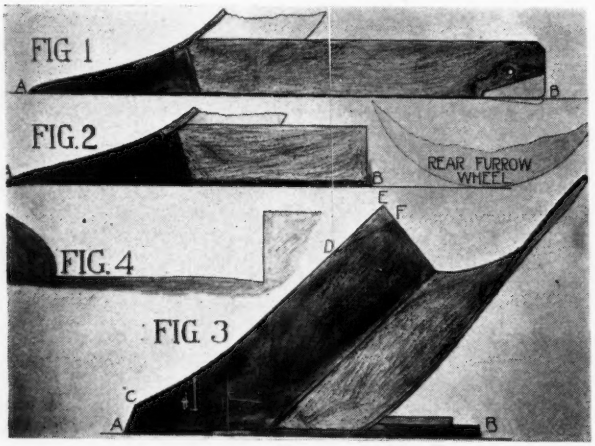


Fig. 1. Landside view of lower part of a walking plow bottom
Fig. 2. Landside view of a wheel plow bottom showing the clearance under the heel of the landside
Fig. 3. This shows the outline common to most plow shares
Fig. 4. This shows how the point of the share depresses itself slightly lower than the cutting edge

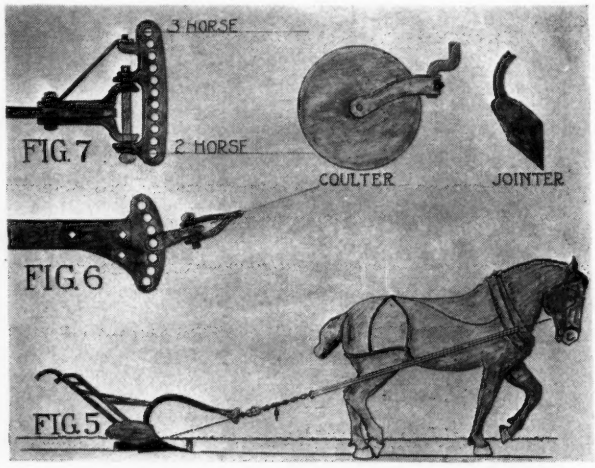


Fig. 5. This shows hitch and line of draft in a walking plow
Fig. 6. Vertical clevis on plow beam allowing hitch up or down
Fig. 7. Horizontal clevis to control width of cut of furrow

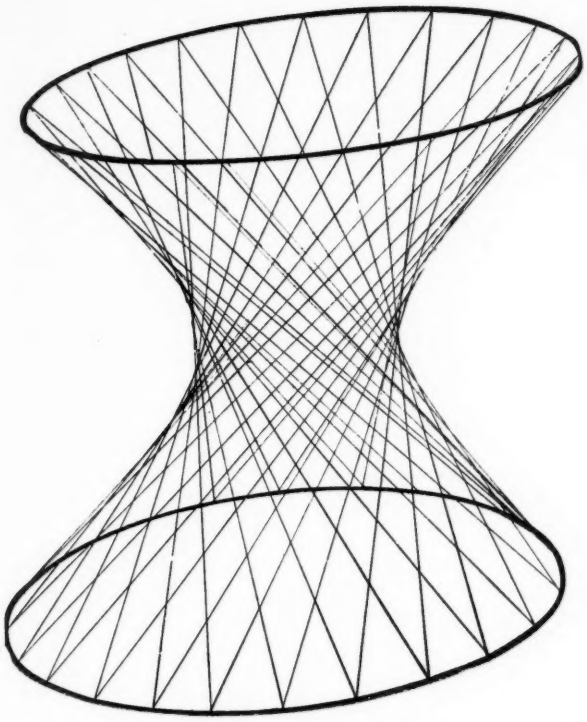


Fig. 8. It has been found that most of the successful plow bottom surfaces designed by cut-and-try methods have equations which approximate that of a hyperboloid of one sheet

The outline of such a surface is shown in Fig. 8. Its equation is $x^2 \div a^2 + y^2 \div b^2 - z^2 \div c^2 = 1$.

So much for theoretical considerations. Practically, a plow bottom may be considered as a three-sided wedge, the flat sides being the cutting edges of the share and of the landside, while the third side of the wedge is that of the upper portion of the share and of the moldboard, which serve to invert the furrow slice.

There are two distinct functions of a plow, the first being to alter the texture of the soil from a comparatively hard compact mass to a pulverized mellow layer of earth in which air and moisture can mingle in every particle. This is necessary for plant growth no matter what the type of soil.

The second function is to bury beneath the surface all growth of weeds, trash and manure. This will cause a more rapid decomposition of the organic matter into plant food.

There are two fundamental forms of plow bottoms, the first of which is designed simply to invert the furrow slice, such as is done with sod. The purpose is to smother the roots and stems in the sod so that they will decay rapidly and to put the soil in a condition of tilth for the production of crops. This class comprises the various breaking plows.

The second is the more common form and has as its primary object the pulverization of the soil.

The types of soil, from the sands, through the loams to the clays, are affected differently by the same plow bottom, and since the prime object of plowing is to put the soil in the proper condition of tilth for the successful growing of crops, it follows that there must be a variety of plow bottom shapes. Also as between sod and stubble plowing there is a difference. In sod plowing the primary requirement is the inversion of the furrow slice, while in the case of stubble, the bottom curvature is more bluff and the soil particles are pitched over and pulverized. In sticky soils the moldboard must have a slower pitch than can be used in the more friable soils.

Drawings showing the curvature at different points along a general-purpose bottom, a breaker bottom, a black land bottom, a stubble bottom and an ordinary sod bottom are given in Figs. 9 to 13.

These curves represent the line made by the intersection of a plane with the bottom, the intersecting plane being at right angles to the line of the junction of the share and the moldboard.

Or, in other words, each curve shows the result which would be obtained by slicing the bottom into sections one inch apart, the plane of the slicing tool being at right angles to the share-moldboard line.

An examination of these figures will show, in as clear a manner as it is possible to show, the characteristic curves of the various types of bottoms. These illustrate the variations in type which are made to meet the varying conditions.

These differences are perhaps more strikingly shown in Fig. 14 where four outlines and curves are superimposed: 1 is a breaker bottom; 2, a stubble bottom; 3, a tame sod bottom; and, 4, a black land bottom.

Penetration is effected by means of the nose of the point of the share, which is designed so that it turns down at the point, as shown in Figs. 1 and 2. As a plow bottom is in reality a cutting tool, it should have the characteristics of a wood or metal cutting tool, of which one of the more important ones is proper clearance beneath the cutting edges. The angle of the point of the share with its proper clearance beneath the point is known as the "suck". The sharper the angle and the greater the clearance, the more suck. There is a working limit both ways to the amount of suck. If there is too little the bottom will tend to run out of the ground, while if there is too much the bottom will jump and jerk. Shares are made with what is known as "regular" suck and also as "deep" suck.

Several factors have to do with penetration. Very hard ground or ground containing gravel and small stones is difficult to penetrate and sometimes make deep suck necessary. Also a lack of weight in a plow can often be counterbalanced by deep suck. It is natural that, if the plow bottom is raised at the heel, the plow will seek its own depth while traveling a shorter distance forward than if the bottom slides along the top of the ground and so gradually works its way in.

Fig. 1 is the landside view of the lower part of a walk-

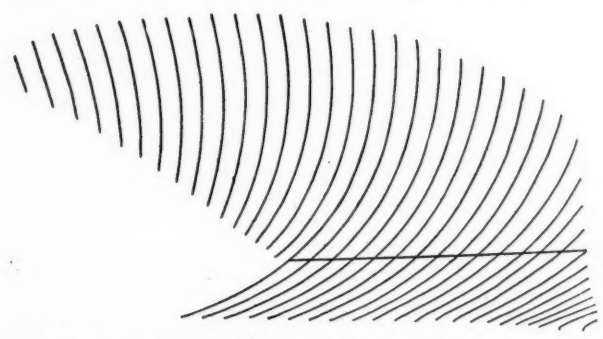


Fig. 9. Characteristic curve of the general-purpose bottom

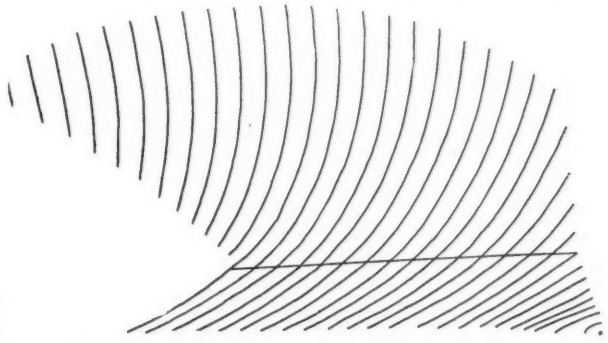


Fig. 10. Characteristic curve of the stubble bottom

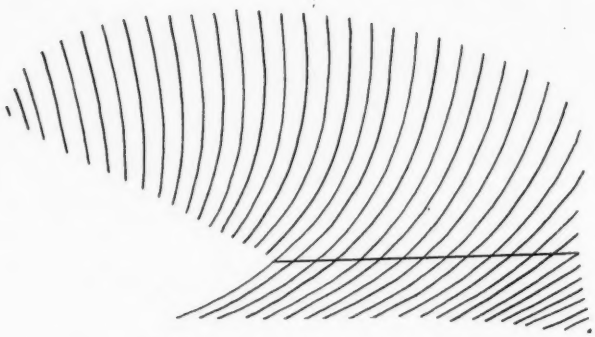


Fig. 11. Characteristic curve of the tame sod bottom

ing plow bottom. The dot and dash line from A to B represents a flat surface with the point A of the share and the heel of the landside resting on this flat surface. The clearance necessary to make the share a good cutting tool is shown by the surface under the landside, which is shaded.

It is common practice in walking plows with steel landsides to use a slip heel made of chilled iron, as shown in the shaded section at B in Fig. 1. It is possible to drop the heel as shown by the dotted line to compensate for wear of the under side of the point at A and still have proper clearance for good work.

When a walking plow is running properly, the heel of the landside makes a slight impression in the bottom of the furrow.

In a walking plow the bottom slides on the bottom of the furrow and so must be supported in a manner to cause it to run true and evenly. Therefore, besides the bearing at the heel of the landside, it is necessary to have the outer edge of the share supported, which is done by what is known as a "wing bearing". This is shown by the surface DEF in Fig. 3. In a 14-inch plow the distance between E and F is approximately 1¼ inches. This wing bearing is very sensitive. Too much bearing will cause the bottom to dip to the land, while too little will cause it to dip toward the furrow.

A walking plow bottom having the points A, B, and surface DEF resting on a flat surface will show a clearance along the cutting edge of the share as represented by the shaded line in Fig 3. It has been found that to make a plow bottom hold to its course, it is necessary for the point of the share to run slightly deeper than the cutting edge of the share, and it is also necessary that the point of the share be a slight distance landward from a point parallel with the landside, so that the correct picture of the cross-section of the bottom of a furrow would not be a horizontal straight line but rather would show a depression where the point of the share buries itself slightly lower than the cutting edge of the share. This is shown in Fig. 4. A deep suck share would exaggerate this depression.

In a wheel plow the weight of the bottom is carried on wheels, and in this case there is clearance under the heel of the landside, as shown at B in Fig. 2. This clearance, as shown by the shaded section, is much greater than that in a walking plow. A wheel plow bottom on a flat surface would have a bearing at AE while B should be raised about 7/16 of an inch.

A word about the shape of shares: Most shares have about the outline as shown in Fig. 3. The angle CAB is slanting enough to let roots and obstructions slide of, and the distance AC is determined as being sufficiently narrow to let the share penetrate and is long enough to give reasonable wear. The line CE is curved inwardly from a straight line. This accentuates the point of the share for penetration. The balance of the cutting edge is straight and at an angle in the neighborhood of 45 degrees to the line of the landside which gives a good shearing cut. There are exceptions; in a black root or alfalfa share the line CE is straight, as is also the case with rice shares. This gives a lesser angle to the cutting edge and, of course, a lesser degree of penetration. For conditions of difficult

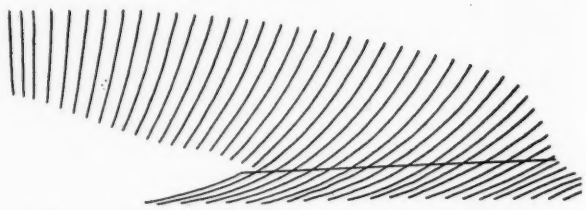


Fig. 12. Characteristic curve of the prairie breaker bottom

penetrability such as are frequently found in the South, there is no point C.

So much for the plow bottom, whose elements must be considered as largely fundamental, and which, except as to detail, the designer should hesitate to change. Given a satisfactory plow bottom, the problem is then to so construct the balance of the plow and provide such a hitch as will make the bottom run properly. I will try to illustrate my point by referring to Fig. 5 which shows a walking plow.

First, start with the plow bottom approximately 5 inches in the ground, with its center of resistance at a point somewhere near the joint between the share and the moldboard.

The power to draw the plow is furnished by a horse, and the point of application of this power is at the point on the collar to which the trace or tug attaches. There must be a reasonable distance between the horse and the plow bottom for clearance and to make the plow run steadily. The draft line is shown by the line AB.

Now, in order that the plow may run correctly at the depth at which it is shown, it is necessary that the point of application of power on the plow should be in this draft line. It is also necessary in a plow that there be clearance for trash and room for the furrow slice, so it has been common practice for years to construct a plow beam which is attached to the frog of the plow and curves up and forward, forming what is known as the throat, and then downward towards the front end.

The height of the under side of the front end of the beam above the plane of the bottom is usually from fourteen to sixteen inches.

It is necessary to have on the front end of the plow beam a vertical clevis, shown in Fig. 6, which allows a hitch either up or down. The only method of plowing at different depths with a walking plow is to raise and lower the hitch on this vertical clevis. If the hitch point is raised, the line of draft will then extend through the higher hole in the clevis and the front end of the beam will be forced down, causing deeper plowing, while, on the other hand, by hitching lower the line of draft extending through a lower hole on the clevis will force the front end of the beam up and the furrow will be shallower. This general proposition of the line of draft is the same for all types of plows, and when this point is understood it is easy to make the correct adjustment for proper plowing depth. The line of draft tends always to be in a straight line.

By referring to Fig. 7, it will be seen that in addition to the vertical clevis, there is also provided a horizontal clevis. The purpose of this clevis is to control the width of cut. By hitching to a hole further towards the land the furrow slice will be narrower, while hitching closer to the furrow, the furrow slice will be wider. On a clevis as shown provision is made for both a two and three-horse hitch,, the three-horse hitch being near the land end of the clevis. It is always desirable to walk the furrow horse in the middle of the furrow.

Handles are attached to the plow bottom for the purpose of guiding it. The more difficult the plowing and less wing bearing there is, the longer the handles should be in order to make it easier for the operator. Sometimes a gauge wheel is attached to the front end of the beam, to keep the front end from going beyond a predetermined depth. At other times a shoe is used for this purpose. Where conditions are favorable, a rolling coulter is used to cut the furrow slice. The coulter should usually be set so that it cuts about ⅝ of an inch further to land than

the plow share, so that sides of the furrow will be clean In general, a coulter set two to three inches back of the point of the shares will do the best work and cause less difficulties in penetration, although when trash is encountered a rolling coulter set further ahead will help cut the trash better. In conditions where there is gravel and small stones a jointer is substituted for the coulter.

There is very little fundamental difference between the various walking plows manufactured today. They all have the general features shown.

In considering wheel plows, it may be interesting to draw a diagram showing the fundamental features of a plow which must be considered in the design. In this instance we may take a two bottom tractor plow or standard design suitable for use with any tractor.

We will first locate the two bottoms. These bottoms will be rigidly fastened together. In the case of a 14-inch plow they will be spaced 14 inches apart sideways, while fore and aft they may have any spacing between 14 and 20 inches depending upon the amount of fore and aft clearance desired. This clearance should be sufficient to allow the furrow slice an unimpeded path.

Next, these bottoms must be provided with beams of the same general appearance as the one of the walking plow shown. They will naturally extend forward substantially parallel to each other and must be braced together in order to hold the bottoms rigid. Such bracing will have to be so placed as to be out of the path of the furrow slice.

Next, this plow frame will have to be provided with wheels, one wheel to run in the furrow, either in the corner of the furrow or approximately so, and further, it must be far enough ahead of the front plow bottom to give clearance for the furrow slice. This distance must be at least twenty or twenty-one inches. This establishes rather definitely the position of the furrow wheel. On the opposite side, or on the land, there must be provided a land wheel, the position fore and aft of which is limited between certain distances. If too far back, the hitch of the plow will be too sensitive, and if too far ahead, its effect as a gauge wheel for depth will be destroyed. There must also be a rear wheel which will run in the furrow. Usually this wheel runs at an angle, and often in the corner of the furrow, to take landside pressure off the plow bottom. There must be a cross clevis of some kind at the front end of the beams to allow a lateral hitch so that the plow may cut more or less land, and also to adapt itself to different types of tractors. There must also be up and down adjustment at the front for varying depths of furrow and for accommodation to various heights of drawbars on tractors. There must also be provision for rolling coulters, and jointers if they should be needed.

From this point on the designer has an opportunity to show his hand. He can spend his ingenuity in working out a convenient and effective lever system, a reliable power lift and a satisfactory rear lift, and should keep in mind constantly, cost, appearance, ease of handling and reliability.

It hardly seems necessary to consider any other of the well-known types of plows. The principles to be considered are the same. What I have tried to point out is the fact that a rather definite course is laid for the designer to follow in the creating of a plow structure. There is a background of years of work on plows that is not to be forgotten. There are three subjects—simplicity of construction, convenience of handling, and compactness—which will give a chance for the display of originality and ingenuity by the plow designer.

There seems to be less of a chance of improving the bottom itself than of the rest of the plow. Of the bottom itself, possibly the greatest chance for improvement lies in the further research work along the line of improved materials. At present soft center steel gives the hardest and densest surfaces of any steel, while chilled iron is the hardest form of cast iron.

While the present types of plows seem to us remarkably efficient implements, yet it is probable that the years to come will witness important changes. Just what these will be is difficult to forecast, but I will be bold enough to predict that some day in the future:

1. Plow bottoms will be developed from formulas worked out for various soils and conditions in which X, Y, and Z are, so to speak, soil constants.
2. That plowing units will be very compact, with a minimum of moving parts and closely associated with its tractive power.
3. That materials will be developed having qualities better adapted for plow bottoms than are now known.

In conclusion I wish to put in an earnest plea for the designer. Don't discourage, but rather help him to keep his enthusiasm. If his enthusiasm is allowed to wane, his creative effectiveness will stop.

Discussion by A. C. Lindgren

MR. BROWN has defined clearly and in a general way the basic reasons which control several features of moldboard plow design. There is really little left to be said on the general points brought out.

It may be of interest, however, to supplement this paper by enumerating some of the controlling reasons for modification of such plow design, and why one or two types will not meet all requirements.

It may be interesting to mention briefly a few of the outstanding features the designer must consider when building some of the other soil handling machinery, covered by the subject of this paper.

The designer should have a broad understanding of the general requirements of the article he is building, or he will produce an article which fills some local demand thus making quantity production impossible. He must have fair knowledge of foundry practice, as many parts on farm machinery are made in the foundry. He must be familiar with forge shop methods, of shaping steel parts, have good judgment in regard to the use of various materials such as soft steel, high carbon steel and he must be acquainted with the heat treatment of steel. The individual parts must be so designed that ordinary mechanics can produce them, and these parts must be capable of assembly with little expense and trouble.

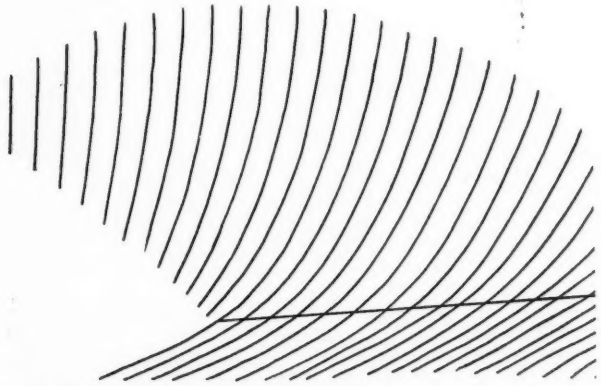


Fig. 13. Characteristic curve of the black land bottom

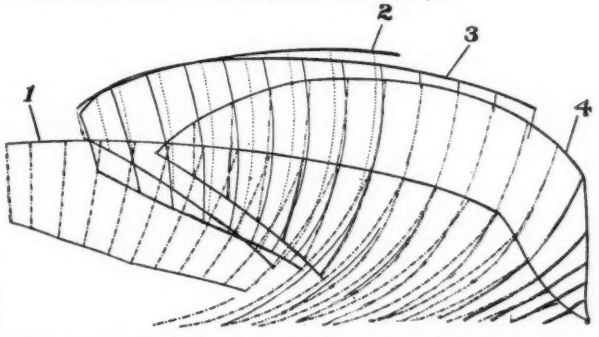


Fig. 14. Four plow bottom outlines and curves superimposed: 1, breaker bottom; 2, stubble bottom; 3, a tame sod bottom; and, 4, a black land bottom

The successful designer must produce an implement that meets the popular demand, and one which does the work it is intended to do. It must be light, yet strong enough to withstand the abuse it receives in the field. Most important to the manufacturer is the final cost, which must be low in order to leave him a reasonable profit.

A few of the outstanding features affecting the design of various soil handling implements are as follows:

Drag Harrows. The question of cost is probably the most important, as this type of harrow is generally sold on close margin. The teeth must be arranged to produce equal space longitudinally, when drawn straight forward, and if used on hillsides, where the harrow as a unit drifts downward. Where it is drawn cornerwise, the teeth must not line up giving wide spacing. The drawbar must be designed in such a way that a farmer having a four-section harrow can use parts of this drawbar for either three or two sections.

Disk Harrow. One important item is cost, another durability. The bearings must be particularly durable, with convenient oiling facilities. The harrow must be flexible for uneven surfaces, and some form of anti-tilting devices must be used to prevent the side thrust of each gang from raising the inner ends of an outthrow harrow. The design of the standards between the disks and the scrapers must receive special attention, to prevent clogging between disks in sticky soils. At present the foot operated oscillating scrapers have been accepted as the most practical type.

Tractor Disk Harrows. The scraper at present troubles the designer considerably, as the operator is some distance from the harrow and cannot operate the scraper by foot.

Tractor harrows must have a quick and positive means for adjusting the angle of disk gangs. The double-cut harrow must have proper flexibility between front and rear sections to permit free and easy turning, yet sufficient lateral rigidity in straight away work to locate the rear disks in the proper place behind the front disks.

Summer Fallow or Field Cultivators. The designer must provide sufficient clearance between the teeth to permit trash to pass through, as these cultivators are generally used in extremely weedy conditions. Certain territories demand spring tooth equipment; other territories require the stiff bean with spring trip; some require sweeps, others shovels. The hand lift on a horse-drawn cultivator must be easy to operate and the power lift on larger tractor-drawn units must receive his attention.

Row Crop Cultivators. This type of machine must have sufficient adjustment between the wheels to fit as many varieties of row crops as possible. Various shovels or sweeps, which are the digging elements, must be provided, and the designer must have an intimate knowledge of the various gang equipment for different territories, whether it is four shovel, spring tooth, or eight shovel.

On the one-row, present day corn and cotton cultivator, which is usually a foot control, special attention must be given to quick and easy guiding means to keep the cultivator on the row. He also has that troublesome feature to overcome, namely, to balance the cultivator when the operator remains on the seat and raises the gang as when turning. The draft equalizer on a one row cultivator is not difficult, but gives him considerable food for thought on a two-row cultivator implement drawn by four horses. The cultivator hitch should be low to prevent neck weight. This low hitch on a four-horse, two-row cultivator is impossible, as the evener must pass over the top of the outside row; a low hitch at this extreme outside point has been almost impossible to attain. Many designers have made attempts, but this form of equalizer has invariably proven weak. The designers at present seem to have accepted the truck to carry this neck weight, when four horses are used, using a high equalizer extending in a horizontal plane over the top of the plant.

The designer in order to meet requirements must consider the so-called whims of different territories, such as separate levers for moving laterally each pair of gangs; a single lever for moving both pairs of gangs simultaneously in opposite directions, and still another request for a fixed adjustable spacing between the gangs, with lever control for adjusting the gangs to and from the plant row. These various requests are very annoying to the designer, but must receive careful consideration.

Potato cultivators require four horses abreast as the cultivating is usually deep, using four shovels 14 inches long. The designer's first consideration is therefore suitable strength.

Inasmuch as the most popular size of beet cultivator is the four-row type, varying in distance from 16 to 24 inches, the designer must provide convenient adjustments to permit setting the sweeps and duck feet ot various kinds on the tool bar in proper position. He must also provide an efficient guiding means to enable the operator to follow the rows accurately since the cultivating implements are usually set very close to the plants.

In the case of sugar cane cultivators, three types are popular: the walking-shovel type, the riding-disk type, and the tractor-cultivator type. The first two require close and variable adjustment of the distance between the wheels. When the crop is young and immediately after it is barred off with walking plows, the wheels must then be spread far apart to straddle the row. Later, when the crop it too tall to straddle, the wheels must be set together, since the cultivator is operated between the rows and the position of the gangs reversed. Special moldboard shaped shovels to move the earth toward the crop are used. The proper design of a disk cultivator for sugar cane is probably a more difficult problem for the designer than the walking cultivator. The tall crops call for very high wheels, usually 54 inches, and a very high frame, with an unusual amount of lateral adjustment of the wheels and gangs.

Tractors sufficiently narrow to operate between cane rows have recently entered the sugar cane territory and to make all possible use of this tractor the designer is called on to build a combination barring off and cultivating implement. The barring off of stubble cane is done by means of plows, right and left operated, on each side of the cane row. Later, for cultivating between the rows, these plows are replaced with a set of cultivator disk gangs and a middle buster.

Listers for corn and cotton are a popular type of plow and planter. The lister bottoms, being a double wedge shaped plow, must be properly shaped, as Mr. Brown has mentioned, in order to shed many of the sticky, waxy soil conditions in which corn and cotton is raised. The problem of uniform spacing between the rows has received the designer's attention for some time and out of this the wide tread lister has been developed, where uniform spacing is obtained by operating one of the carrying wheels in the last made trench.

The designer must consider the demand for a two-wheel lister, a three-wheel machine, and a two-row four-wheel machine. He must provide adjustable spacing between the rows, and equip all of these types with an efficient planting and covering device for corn, cotton and very often peas and beans.

Double listing or relisting, which means splitting ridges of previously listed fields, with any lister, gives the designer considerable trouble, as any excessive pressure on one side of the double-faced plow is accompanied by a decrease in pressure on the opposite side, resulting in the lister sliding to one side and out of the ridge.

Disk plows are a popular form of plow in certain territories, where the ground is extremely hard and will not be pulverized sufficiently by moldboard plows or where the soil is extremely sticky when wet, and will not scour on moldboard plows.

The designer must study the proper angle of the disks, the proper distribution of the entire weight of the implement to hold these disks in the ground as disks do not have the suction of a moldboard plow, which point Mr. Brown so carefully discussed in connection with plow bottoms. He must provide the necessary adjustment for width of cut to enable a narrow furrow slice cut when the

ground is extremely hard, and a wider cut when plowing conditions are easier.

The disk plow does not have a landside against a perpendicular furrow wall to take the side thrust as in a moldboard plow, therefore this side thrust must be taken on the wheels. These wheels must be located in proper position with respect to the disks to give them the best possible control of the disks. The plow must necessarily be strong, and if not heavy requires some means of carrying additional weight in hard soil.

The center of resistance or center of draft to balance the side thrust of the disks necessarily must be closer to the furrow than on moldboards, therefore hitching a two-disk plow behind four animals abreast, walking the right-hand animal in the furrow gives the disk plow designer some trouble. The disk bearings must be of proper material to withstand considerable wear, as the bearing pressures are rather high.

The scraper has a double purpose, in wet sticky land to keep the disk clean and also to turn the furrow slice to cover the trash. The moldboard type, being the larger and slightly curved, is popular in easy scouring conditions, but the designer soon learns in Texas gumbo that this type will not scour, therefore he has to provide a smaller flat scraper blade that does scour which is flexibly held against the revolving disk.

Subsoilers intended to penetrate to unknown depths to break up a hard pan must be extremely strong as it is quite common that unusual resistance will stall the outfit. Designers when considering the use of one or both of the carrying wheels as a source of power for the power lift should realize that this power lift is inoperative when the outfit is in plain words "stuck". If the operator attempts to back up, the outfit will jack-knife, therefore it must be drawn out from the rear or unearthed with a spade. It is the designer's job to get around this difficulty. Possibly by designing the machine to release the standard from its upright position when stalled to draw it out of the tight place endwise.

Mr. Brown has mentioned the ideal position and the proper function of the wheels on wheel plows. In some unusual conditions such as plowing under low hanging branches of citrus fruit trees, and close to the body of the tree the designer must place the land wheel considerably forward of the ideal and in front of the rear plow bottom to permit plowing close to the tree. He must eliminate all upstanding levers that may strip the fruit from the branches, and injure the tree. The same is true of the orchard disk plow.

American farm machinery occupies an important position in foreign lands and while these foreign fields may have soils of the same nature as we have here at home, the foreigner, for instance in England, may desire an entirely different type of furrow from his plow. The African uses only oxen as draft animals, and the hitch may therefore have to be modified. His operators usually walk near the center of a span of, say, twenty oxen to properly control them, leaving the plow to take care of itself. very often these animals become unruly, when turning, and the plow upsets; therefore all levers must lay close to the beam of the plow when raised. The Mexican will use only a one handle walking plow; the Frenchman a turn-over, two-way plow. The Argentinian a low-lift riding plow for strung out hitch with a guide lever for the front wheel, conveniently close for use under his poncho in bad weather, and the Australian must have a 5 to 8-furrow stump jump plow to till his soil among malley roots.

Consider for a moment the various crops in this country, and in foreign lands consider the great variety of soils, and the climatic conditions that control in a large measure the proper tillage of fields in this country as well as foreign; also consider the local farming customs in this country and other parts of the world where American implements are sold, and you may have some idea of the implement designer's problem in producing a commercially successful, universal implement. However, the American producer has placed the United States foremost in the design and manufacture of farm machinery.

The agricultural machinery designer may be called a special breed of engineer; his product may seem crude to many engineers familiar to other lines, but nevertheless his products are examples of real excellence in intricate design, probably because his knowledge has been acquired from that wonderful school of experience.

General Discussion

Mr. Bacon: No one needs to say anything in addition to what the two gentlemen have just said, because they have certainly covered the principals of design. However, my work in the line of research has given me a different angle to plow bottom designing and leads to an opinion contrary to a statement that has been made today.

We have found that the size of the moldboard has little to do with scouring. That is contrary to general principles. We have always been led to believe the smaller and bluffer the moldboard, the easier it would scour. We found in some places that the soil itself seems to contain ingredients which cause moldboards to pit rapidly. We have found many other causes for sticking, but in no case have we any reason for believing the size of the moldboard was responsible.

The great problem that confronts manufacturers and farmers today is not so much new design in tools, particularly soil stirring tools, as it is in the more intelligent application. The farmer does not know everything that he can get out of his modern tools.

For instance, a plow can be used in one hundred and ten ways where it is only being used for one at the present time. One little incident illustrates my meaning. A farmer had an orchard that should have been bearing peaches, but wasn't. He asked me to make an examination to learn the trouble with his peach trees. Earlier in the year his peach trees seemed to be normal, but this fall, just before the frost set in, we found on the under side of the leaves of those peach trees millions of aphides, which were not known in that country. In the fall of the year this insect lays its eggs at the base of the latent buds of the trees. In the spring those little insects hatch with the warmth of the swelling buds and suck the sap from them. The trees bloom poorly or not all. In the summer time the insects migrate to the grasses in the orchard and don't return to the trees until fall. By the proper use of spraying outfits and plowing to keep the orchard clean, these aphides must perish.

Information of this sort will mean prosperity to the farmer, and also to the agricultural implement manufacturer.

Another farmer had a field infested with white grubs. I told him he needed a tractor and plow because of the hard work of plowing this particular meadow land. The grub could easily have reduced his crop twenty per cent. He would not plow that field for two reasons: First, he wanted the meadow for pasture, and second, the ground was too hard; he wouldn't bring his horses in that field, but when I told him he could plow that ground during the summer or early in the fall with a tractor outfit and kill the greatest percentage of the white grubs, he seemed amazed.

We need more intelligent application of the tools we already have. Any part of the growing year has some particular use for soil stirring tools. The soil expert and the designer must help the farmer solve the problem. Why? Because they can prove to the farmer that he can make two blades of grass grow where one is growing now.

Nature is constantly changing. Doctors tell us that we change our bodies once every seven years. The soil changes and the farmer must know what the changes are and how to meet them. Our present farm practices have brought upon us these inroads of grief we heard about this morning. It is not the separator or a cleaning device that will rid us of weeds. It is better cultural methods; plowing the ground and cultivating to keep the weeds from growing. Let us pay more attention to a more intelligent application of the tools we already have and less to new design.

The Construction of Twin Storage Cellars

By Norman S. Grubbs

Mem. A. S. A. E. Agricultural Engineer, Portland Cement Association

DUE to the increasing interest in farm storage manifested by the fruit and vegetable growers throughout the State, together with the necessity for storage facilities at the college, two experimental storage cellars under one roof were built by the horticultural and farm departments of Pennsylvania State College during the late fall of 1924. Farm labor was used exclusively.

After careful investigation of existing storage cellars and a consideration of materials, taking into account adaptability, permanence, flexibility and available materials, it was decided to build of concrete.

For the walls any one of three different types of concrete construction could have been used. One of the most commonly used methods of construction is the monolithic type wall. This calls for concrete placed in forms to make a solid wall of a definite thickness. A second type is the block wall where standard concrete units containing air spaces are used for the wall. A third type is one in which concrete is used with the aid of movable forms, making double monolithic concrete walls with a two-inch air space between them. This third type of wall was used in the walls of these cellars.

The walls carry a reinforced concrete slab supported by reinforced concrete beams and columns. This slab is 6½ inches thick and was placed as one continuous roof and will carry a load of earth for frost protection of from 2 to 2½ feet thick.

The floor of each cellar is earth except the wash room in the vegetable cellar which is provided with a concrete floor. Both cellars are completely banked with earth, with the exception of the front side, which contains the door and window openings.

The exterior walls are 10 inches thick—four inches of concrete, two inches of air and four inches of concrete. The walls are stiffened by 12-by-24 inch solid concrete pilasters reinforced with three ⅝-inch round bars, 2 inches from the inside face of the wall. Pilasters are 10 feet center to center. The two-inch air space is continuous from the footing to the roof and three feet nine inches long, that is, the two four-inch walls have three-inch concrete ties spaced four feet, center to center. The walls also are tied together with ⅛-by-¾-inch strap iron ties, ten inches long, spaced two feet center to center longitudinally and 9 inches center to center vertically.

The walls are reinforced with ⅜-inch round bars, nine inches center to center, two inches from the inside face. The wall separating the two cellars is nine feet high and twelve inches thick—five inches of concrete, two inches of air and five inches of concrete with no pilasters. Details otherwise are similar to the exterior walls.

Concrete used in the walls was one part cement, two parts sand and four parts stone, mixed with just enough water to form a stiff semi-plastic mix.

Concrete was tamped into the forms and the forms removed at once. The concrete was cured by sprinkling twice daily and covered with canvas. The canvas served two purposes; it prevented evaporation of moisture by day and frost injury by night.

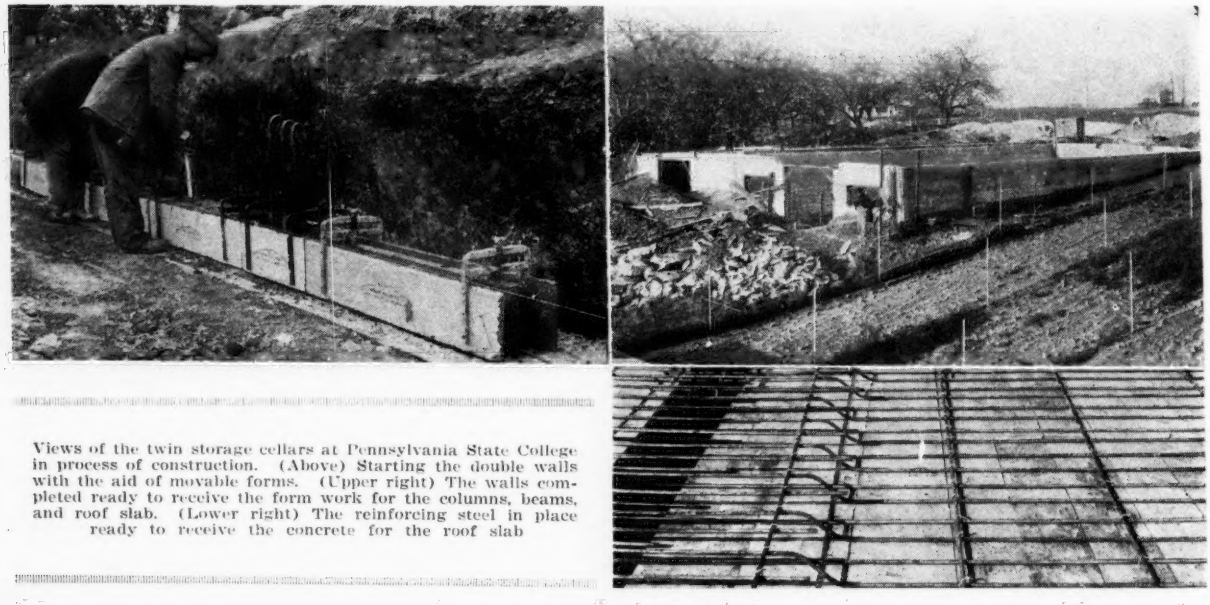
Forms for the reinforced concrete columns, beams and roof slab were built in place. Ordinarily forms would have been built for one cellar at a time but due to the approaching cold weather forms for the entire job were built.

The sheathing was good quality ⅞-by-10-inch and 12-inch yellow pine. All other lumber was run of mill, oak and chestnut, well seasoned, 2 inches thick and in widths varying from 4 to 10 inches. This material was utilized for joists, stringers and shoring, also for column yokes and bracing.

Concrete was placed in twelve columns with time to set before starting to place the reinforcing for the roof slab. The concrete for the beams and roof slab was placed at one operation. In all cases the concrete was thoroughly spaded or tamped into the forms.

All reinforcing steel was received straight. The necessary bending and placing of the steel was done on the job. After the steel for the roof slab was placed and tied together, the entire mass was raised and one inch thick concrete blocks inserted under to permit the concrete to encase the steel when placing the concrete slab.

(Continued on page 133.)



Views of the twin storage cellars at Pennsylvania State College in process of construction. (Above) Starting the double walls with the aid of movable forms. (Upper right) The walls completed ready to receive the form work for the columns, beams, and roof slab. (Lower right) The reinforcing steel in place ready to receive the concrete for the roof slab

Leaching Farm Lands on the Rio Grande Project

By G. A. Altgelt

Mem. A. S. A. E. County Agricultural Agent, El Poso County, Texas

ALKALI is yet to be found in some of the land of the Rio Grande project. This alkali accumulated in these areas during the period of high water table before the installation of general drainage. A large percentage of this salt impregnated land has since been reclaimed but there still remains some unreclaimed new lands and some more or less semi-alkali lands which were in cultivation at one time. To say the least, it is still perfectly feasible to leach the salts from the remaining well-drained alkali lands without excessive cost or loss of time.

The alkali occurring in the Rio Grande Valley of Texas and New Mexico is composed principally of sodium chloride, sodium sulphate, calcium sulphate, magnesium sulphate, lime carbonate, lime chloride and magnesium chloride. These salts make up what is commonly called "white alkali" which is much less harmful to plants than the so-called "black alkali" which consists of sodium carbonate and sodium bicarbonate. The so-called black alkali spots appearing on the surface of the ground in this valley are due to lime and magnesium chloride. These salts are delequescent, that is to say, they are able to absorb moisture from the soil and atmosphere, giving the dark tint or chloration commonly noticed.

There is but one practical method of removing alkali from soils and that is through leaching well-drained land. These salts are brought into the soil dissolved in water, and they must be removed in the same way. Ground water in seeped lands rises to the surface by capillarity, evaporates and leaves the alkali in the soil. To remove the alkali, it must again be dissolved in water and the water with the alkali in solution carried down through the soil and away through the drainage, simply reversing the process by which the alkali got into the soil.

There is a persistent popular belief that certain crops, such as sugar beets and sorghum, will remove large quantities of alkali from the soil. The amounts of alkali which these or any crops will remove is negligible, and the farmer should waste no time in trying to reclaim alkali land in this manner. Cases may be cited where such crops were planted with apparently good results, but if so the improvement in the land was due to the salts being leached down by the irrigation water and not due to the alkali being taken out by the crops, as may have been supposed.

Likewise, alkali can not be removed by merely running water over the surface, unless the soil is quite porous and enough water is applied to carry the salts downward the desired depth, which would in reality amount to leaching, as the salts, after all, are carried downward through the soil and are not carried off by the water which passes over the soil without entering it.

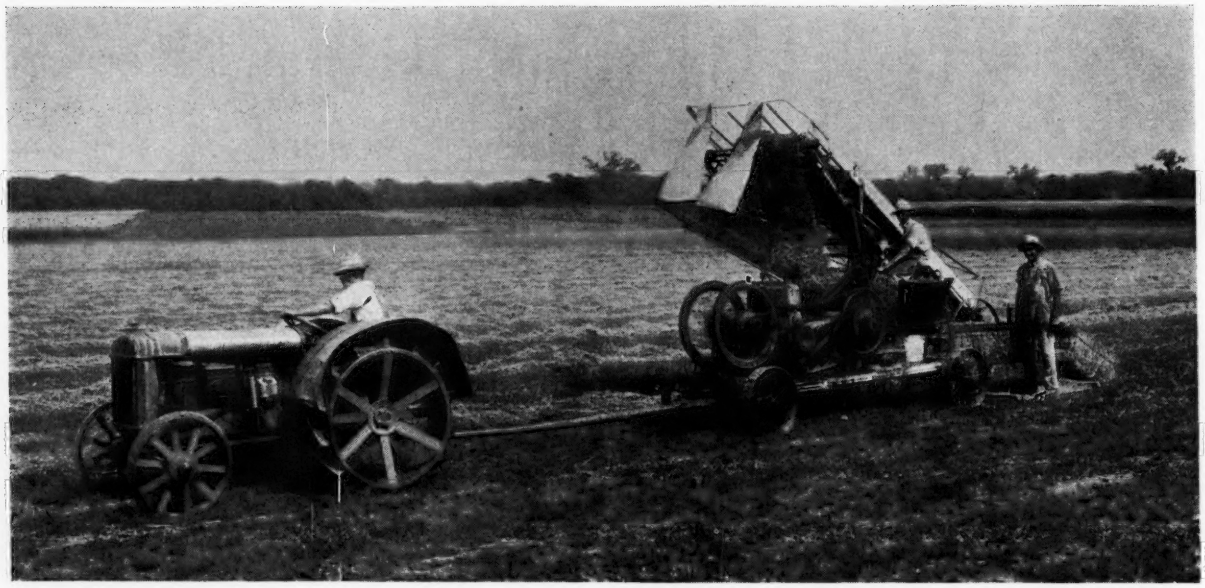
Before attempting to leach a piece of alkali land, a thorough examination of the area for alkali should be made to ascertain beyond resonable doubt that it can be successfully leached. A sufficient number of borings should be made with a soil auger, post hole digger or other means, to determine the character of the soil and depth to ground water. The depth of the water table, and is, the distance from the surface to the point where standing water is encountered, is the most important part of the examination. On local soils it is known that, if the depth to the ground water is four and one-half feet or less, the reclamation is doubtful and the degree of uncertainty increases in proportion to the shallowness of the ground water. Such soils lie within the range of capillary lift and if leached the salts would soon accumulate again. There is no absolute depth to ground water which may be said to mark the danger line. The depth will vary with the type of soils. Water will rise farther by capillarity in heavy types of soil than in lighter types. If the surface of the ground water is encountered in a subsoil which is not real porous it will require some time for the ground water to find its level in the test hole.

Therefore, the measuring of the depth to water should be made several hours, or a day after the holes are bored. In making borings, it is necessary to examine the soil which comes from the hole every time the auger is removed. Bear in mind always that the denser the soil, the slower will be the process of leaching. For successful leaching, the soil must be sufficiently porous to permit the percolation of water deep into the underlying strata. Some soils light and porous at the surface may have a stratum of adobe below the surface which will render leaching very slow. As a general rule, however, alkali soils are porous, because it is the porosity of the soil which permitted the accumulation of alkali in the surface soil in the first place. It is to be remembered that the Rio Grande project was subjected to a high water table for only a few years and that before this period lands generally were not alkalin. Very heavy soils, in which the movement of water is very slow, do not accumulate alkali rapidly when subjected to a high water table. If an adobe soil is encountered for the first twelve inches no special note need be made of the condition, as such a layer of adobe is common in the valley and it will not retard the leaching to any extent. If, however, there is a considerable accumulation of aklali and a heavy adobe is present in a much thicker layer than this, leaching will probably be retarded to a considerable extent. The ideal soil for leaching is one which is sufficiently porous to permit the normal percolation of water. When soil is examined for porosity it should be borne in mind that all admixtures of adobe and loam are called adobe. The very finest and purest silt is often highly resistant to percolating water. Between the depths of three and ten feet over the valley a coarse silt will be encountered. This is the water bearing formation through which drainage water moves laterally rather freely to the drainage ditches and it is because of this stratum that the alkali can be removed.

While the boring is being made it will also be well to taste the soil from time to time to see if the salts can be detected. As a general rule this will give good information, although if no salt can be sensed it should not be taken that alkali is not present. If, on the other hand, a distinctly salty taste is detected it is proof sufficient that a harmful amount of alkali is present.

More definite information, however, can be secured by taking samples from each foot of soil to a depth of four feet. A small cupful of soil is sufficient for each sample. With these samples, a soil chemist can determine the exact percentage of alkali present at the different depths. Such determinations are not considered essential any more, however, because if alkali is known to be present then it follows that the soil should be leached before successful farming can be undertaken. Such tests would serve a better purpose if made after the leaching operation has been thought to be completed, to determine then if the alkali has been washed out.

The determination of alkali on old lands includes all the detail examinations recommended for new lands but special attention should be called to one or more points. Old lands which have been under irrigation and cultivation may never have been leached in the beginning, or it frequently happens that the leaching was poorly done. If this land has not been plowed previous to the examination the problem is simply to proceed as for examining virgin soils for alkali. It is not unusual to find the alkali in spotted areas



Harvesting hay in Kansas by a rather unusual method. The alfalfa is thrown into windrows by hitching two side-delivery rakes back of the tractor. The tractor is then hitched to the power baler, which in turn has a side hitch for a hay loader. The hay loader then elevates the alfalfa from the windrow to the automatic feed on the baler, and in this way the hay is baled directly from the windrow. By such a method very few leaves are lost from the hay, and it has proven very satisfactory for harvesting late crops of alfalfa in Kansas. Photo courtesy H. B. Walker, Kansas State Agricultural College

in such fields. If the field is planted one can rest assured that alfalfa, cotton and other crops will not grow vigorously in the presence of an injurious impregnation of alkali. If on the other hand the soil is in a plowed condition the examiner will have to depend on borings alone. The tests will have to be more frequent and it might be well in this case to have a soil chemist determine the amount of alkali present. Any percentage of over one-half of one per cent of alkali would mean that the soil will have to be leached before normal crop growth can be obtained.

It must be borne in mind that the leveling of land for leaching and the leveling of land for border irrigation are undertaken with two distinct purposes in mind. In border irrigation the land may be prepared practically level, or it may be prepared with a decided grade. This will depend on the porosity of the soil or the capacity the particular type of soil has for absorbing water. On a highly porous soil it would be poor economy to go to considerable expense to level a field as flat as possible only to learn that the soil under such conditions absorbs more water than the plants can use and that the checks will have to be made extremely short, to correct the situation. Such leveling for leaching, however, has but one consideration and that is the leveler the land the more rapid the absorption of water will be on all soils and the quicker the leaching will take place.

It is highly important then that the area to be leached be in a comparatively level block or that, in the case of a large field which does not lie in the same contour, the land must be divided into level checks, or terraced borders. The border surrounding each check should be at least one foot high after settling. This will require the border to have a base about three feet across, the width depending upon the soil out of which the border is built. The top of the border should not be less than one foot in thickness. Care should be taken to see that there are no high spots left in the field. This is essential because the high spots would not be covered to an even depth with water with the result that as the water recedes, leaching would cease in the high spots as soon as they were above water and alkali would accumulate on these high spots from the time they emerge above the standing water until after the water had disappeared from above the surface of the adjacent land. The land should be prepared so that the water can cover the surface to be leached in as even a sheet as possible.

A farm level is essential in this work and is used by practical farmers and contractors engaged in leveling land for irrigation. The first thing the farmer should do is to make estimates, through observations and calculations made through the aid of the farm level, of how many yards of dirt will have to me moved from cuts into fills. When this is done the farmer will know approximately how much the cost will be. The land is then cleared of trees and stumps, plowed and leveling begun. The dirt is generally moved with a four-mule Fresno scraper. After the area has been approximately leveled, the instrument is again used and grade stakes or level stakes are placed over the field to denote the low and high spots. It must be borne in mind that a farm may be leveled several distinct ways.

It frequently happens that land to be leached can be flooded to a greater depth than ten inches with very little extra cost. Drainage ditch banks, natural terraces and other barriers may practically surround such land, in which case the extra cost of preparing the land for a deeper application of water will be highly justifiable. It is always to be remembered that the greater the depth of water applied for leaching, the more the water pressure will be and the quicker leaching will take place.

Time is not a factor in leaching alkali from soils in the sense that any area need only be subjected to leaching for a given time. It is the dissolving and transportating action of the given quantity of water which passes down through the soil column which does the work. Inexperienced farmers might do well to mark the level of the water after a check is filled so as to be able to note the descent of the water into the soil. Once a check is full of water and leaching is proceeding normally it is highly desirable to keep the land constantly submerged. Time is only lost by allowing the water to entirely disappear before refilling the checks. Evaporation from the water surface in this climate will amount to from one foot to six inches per month depending upon the season. It occasionally happens that leaching at first may go on successfully and then practically cease on a given area. In such cases it is often found very beneficial to allow the area to dry and then to replow such puddled land deeply before applying water again. Immediately after the leaching process has been brought to a successful close the land should be worked into a good seedbed. It may then be planted with a test crop such as wheat, or if the farmer is reasonably sure that a uniform job of leaching has been done, a good

mulch may be maintained on the surface and the land put into whatever crop is desired the following season.

The best time for leaching alkali soils will not depend upon season so much as it will on opportunity. In some communities and under some conditions leaching water may be available at various times of the year. This information is best obtained from the manager of the water user's association; otherwise the best time to leach land is during the fall and winter. Surface evaporation will be least at this time of the year, and the farmer will be less busy then than during the spring and summer months. This will also be a good time of the year to follow the leaching with a test crop of some small grain, which is adapted to the valley.

There is not much extra expense to the leaching operation other than the labor of the farmer and the use of teams and tools. In that most of the cost of leveling is required for proper irrigation anyway, this cannot be counted as an extra expense. The high and heavy borders are the chief extra expense. The charge made for water for leaching is only ten cents per acre-foot with a two-acre minimum. As a further inducement to land owners, the El Paso Water Improvement District No. 1, waives certain charges on reclaimable lands during the time leaching is being done, if proper methods are followed.

It is highly desirable to leach alkali impregnated lands because normal plant growth cannot take place until these salts are removed. There still remains much land in these valleys which are not producing satisfactorily because of the presence in the soil of varying amounts of alkali. This decreased production is often shown by poor stands, bare alkali spots and undersized or stunted plants.

An Example of Waste in Tile Drainage

THE accompanying picture illustrates an excellent example of waste of hard-earned money in tile drainage. It shows an old tile drain with new tile strung along the line of the ditch. The original drain was not properly installed and the work not only had to be done over again, but the extra cost of taking out the old tile was so great that it would have been almost as cheap to leave them where they were and lay the new drain alongside the old ones.

The natural question is, "What is the matter with the old tile drain?" R. L. Patty, professor of agricultural engineering, South Dakota State College, found there were just three things the matter with it. The picture shows the inlet of the tile drain and the slough that is being drained. The water enters the tile just to the left of where the tiler sits. What the drain amounted to was simply to act as a culvert for carrying off the flood water. That was the first and worst thing the matter with it. Another thing the matter was that the tile were laid by guess. The third thing the matter with the drain was that the tile was two inches too small for the size of the basin to be drained.

More money has been wasted the country over by using this culvert system than in probably any other way. Mr. Patty says that nine out of ten landowners in South Dakota want to drain this way until it is explained why it is not effective; he has found the accompanying picture a very good argument for showing them why this method is wrong.

The reason that the so-called "culvert" method of tile draining is not effective, even if the tile are large enough, is that they do not carry off a sufficient amount of the ground water. During a wet season the ground is full of water and when it rains the water begins to show on the surface. If the tile are laid three and a half to four feet under ground, after a heavy rain is over the flood water disappears rapidly from the low spots and the tile keep on drawing the gravitational or excess water out of the soil. A reservoir is thereby provided that will take up most of the next rain before water shows on the surface of the ground.

The first tile drain installed to drain this slough was nothing more than a culvert. This picture shows the tiler about to start putting in a drain according to the agricultural engineer's recommendations for best drainage practice

The tile drain shown in the accompanying picture is on a farm in McCook County, South Dakota. In seven consecutive years the crop was lost in this slough after the first drain had been installed. The tile was too small, but they would have saved the crop three out of the six years if the system had been properly installed. After the new drain was put in this slough, the owner claimed that he got a crop of sixty bushels of corn to the acre the first year, which was rather a poor corn year.

Thousands and thousands of dollars are wasted yearly by improper installation of tile drains. On the other hand, extension agricultural engineers are saving the farmers of America hundreds of thousands of dollars by pointing out the right practice in drainage installation and by the discouragement of practices such as that shown in the accompanying picture.

The Construction of Twin Storage Cellars

(Continued from Page 130)

Canvas or tarpaulins were stretched over the newly laid concrete to protect it from frost injury as well as to eliminate evaporation of moisture in the concrete.

For the 34,700 cubic feet capacity it required 3,618 total hours of labor, or reduced to 1000 cubic feet capacity units it required 104 man-hours of labor.

Excavation and grading is not included in this summary. All figures are based upon materials delivered upon the site of the job.

MATERIALS REQUIREMENTS

	Cement -bbls.	Sand -yds.	Stone -yds.
Footings for walls and columns (1:2:4 mix)	31.0	9.2	18.7
Beams, [illegible] and roof (1:2:3 mix)	185.5	55.0	82.7
Double walls (1:2:4 mix)	112.2	33.0	66.0
Wing walls, vents and parapet wall (1:2:4 mix)	20.0	6.0	12.0
TOTAL	348.7	103.2	197.4

FORM LUMBER

Sheathing for columns, beams and roof	7,400 board feet
Rough lumber for joists, stringers, shoring, etc.	8,000 board feet
TOTAL	15,400 board feet

REINFORCING STEEL

Steel required for roof slab	6.9 tons
Steel required for walls, pilasters	0.7 tons
TOTAL	7.6 tons

Research in Agricultural Engineering

Research activities in the agricultural-engineering field are presented under this heading by the A. S. A. E. Research Committee. Members of the Society are invited to discuss material presented, to offer suggestions for timely topics, and to prepare special articles on any phase of agricultural engineering research

A Method of Studying Soil Stresses

By M. L. Nichols

Mem. A. S. A. E. Professor of Agricultural Engineering, Alabama Polytechnic Institute

and J. W. Randolph

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NOTE: This is a progress report on the tractor lug experimental work at the Alabama Agricultural Experiment Station being carried on by Profs. M. L. Nichols and J. W. Randolph. This report is an absolutely new contribution to the fundamental mechanics of agricultural engineering and one which is of widespread importance in the development of tractor machinery. It is an outstanding example of how a relatively small amount of fundamental study made it possible to solve a problem which years of miscellaneous testing of the comparative value of different sizes, types, and shapes of tractor lugs was unable to accomplish.

SOIL stresses and their relation to strain and shear are of fundamental importance in a great many phases of agricultural engineering. This is true in the processes of plowing, soil fitting, seedbed preparation and traction, and under the more static conditions of footing construction for foundations, roads, and embankments. No satisfactory method of studying the action of forces applied to soil which were applicable to farm machinery studies could be found by the writers. The method herein described was developed early in 1924 at the Alabama experiment station to determine the action of tractor lugs no soil.

A review of the available literature revealed promising methods, developed in research in closely allied fields. Experimentation, however, proved that these were not adaptable to the kind of problem at hand. Goldbeck (1)* developed a cell by which the pressure at different points in the soil could be determined by the force required to separate two electrical contacts. This method, while satisfactory for the specific use to which put, was too unwieldy for traction studies. Moreover, soil pressures are not distributed equally in all directions, as is the case with fluids, which was obvious from numerous examples of arch action. A few tests with this kind of cell indicated that reliable results could be obtained only when the force was applied perpendicularly to one of the faces of the cell, which is in keeping with the fundamental method of the resolution of a force into different components by vectors.

McCollum and Peters (2) developed an electrical telemeter by which the stresses in girders and various structural members could be measured very accurately by the flow of electricity through carbon piles but no satisfactory method of applying this principle to soil stresses was found.

Investigators (5) have studied the arch action of soils and while the action of a lug is materially affected by this arch formation, these methods were not considered applicable to the problem.

Goldbeck and Bussard (3) recently have studied the supporting value of soils, as influenced by the bearing area, by observing relative penetrations and have arrived at the conclusion that $p \div P = \sqrt{a} \div A$, in which p and P are penetrations resulting from the application of a constant unit load to areas a and A. While the pressure distribution obtained in these studies is of value in studies of lug action, the method itself does not possess sufficient elasticity to readily applied to the problems at hand.

Methods Tested

In addition to experimenting with the methods mentioned above, studies were made with spherical rubber cells attached by pressure tubing to gauges, and cells made by covering funnels with rubber diaphragms. The vectoring of the forces in the soil rendered these impractical. Surface determinations by careful measurement of input and output correlated with slippage and shear areas gave some indication of what was taking place but were of value in comparative testing only. No definite conclusion of what the ultimate lug should be could be found. Putty balls and variously colored materials embedded in the soil showed something of the soil movements under lug action, but the manipulation of such methods was so difficult as to make them impractical.

The Plaster Cast Method

A method was finally developed which has already given indication of much value and which seems to offer possibilities of supplying the information necessary for the design of lug equipment on a sound basis. In this method the soil is placed in a box in uniform evenly compressed layers. These layers are separated by sheets of very thin paper, treated to give as little resistance to shear as possible. Any material which will enable the experimenter to seperate the soil into layers for casting may be used. While the layer may be placed in any plane, for the experiments tried they were used perpendicular to the soil surface and at right angles to a plane passing through the center of the entire rim of the lug wheel. The soil block is then placed in the testing machine and the tractor wheel is run forward until the lug has passed through any desired amount of soil. Exact readings of the amount of force

Action of a rear-inclined lug (39) shearing its way into a soil block, 2 mm. contour. A forward-inclined lug (40) shearing its way into a soil block. A and B are negative surface casts; C and D are distortion blocks

*Figures in parenthesis indicate reference at the end of article.

Rear-inclined lug (35) started in full contact with soil. Rear-inclined lug (36) shearing its way into soil, 2 mm. contour. A and B, negative surface casts; C and D, distortion blocks

delivered to the wheel, its output in tractive effort, the weight and other factors of the tractor are recorded by equipment specially designed for that purpose by members of the Alabama station. The machine is then removed and the surface and lug imprint cast in plaster of Paris. Following this, the soil is removed, one layer at a time, and each successive layer cast in plaster of Paris. Thus the entire soil block is accurately (at least well within the probable error of other soil measurements) cast into blocks, the surfaces of which follow the distortions produced in the sheets of delicate paper. These casts are studied and marked into contours or lines of equal distortion or pressure. The relative thicknesses of the casts at any point give a measure of the pressure at that point and the entire soil movement is entirely visible and in a permanent form for study.

The action of various lugs on entering the soil can readily be determined and the depth and width of this action is also permanently recorded.

The photographs show preliminary casts made to determine the correct place to start different lugs for comparative studies with different weights, moisture contents, particle size, and similar factors. The black lines are contours or equal distortion areas made with reference to the plane of the soil block. In general, their shape shows quite conclusively that the soil block which shears off as the lug enters the soil, exerts a considerable influence on the shape of the areas of equal strain; and indicates that for all the lugs tested when this primary action is passed, they act practically as a straight lug. Other casts show plainly the vectoring effect of tractor weight and promise a fairly conclusive means of arriving at the true value of the factors concerned.

A great advantage of this method is that the strain areas are in permanent form for study and when a new fact is discovered, soil blocks can be referred to at any time. This is of the greatest benefit, for mathematical calculations can be made and checked on actual surfaces. For purposes of study, these contours (which are accurate to 0.05 mm.) may be drawn on coordinate paper directly by means of the Camera Lucida or may be reproduced by any photographic process.

The only serious objection to the method is the introduction of artificial layers in the soil. This is not so serious an error, however, as it would appear if shear areas are any indication of the effect of these layers. The shear areas produced when this method was used and when these delicate papers were omitted appeared to be practically the same. No indication that this altered the results could be found and when the difficulties of mixing uniformly, moistening and equally compressing two boxes of soil were considered and tried, it was concluded that this difference was within the probable error. Moreover, it should be borne in mind that methods of this kind are only of value in determining general fundamental principles of soil reaction which should be checked with supplementary field tests before conclusions from them are used by the designer.

A B C D E

This series of photographs show the effect of weight on distribution of distortion. All the samples used were equally compressed. All lugs ½ inch forward travel.

A—weight on wheel, 90 lbs. per inch of width; 150 lbs. pull
B—weight on wheel, 45 lbs. per inch of width; 120 lbs. pull
C—weight on wheel, 22½ lbs. per inch of width; 105 lbs. pull
D—weight on wheel, 10 lbs. per inch of width; 85 lbs. pull
E—weight on wheel, 2 lbs. per inch of width; 50 lbs. pull

Summary

None of the available existing methods for measuring the stresses and strains in soil due to lug action were found to be satisfactory. It was impossible to introduce any pressure measuring device into the soil that would not also introduce artificial conditions affecting the results. Thin layers of paper treated to reduce their shear resistance apparently did not materially affect the results. The distortion of these layers gave a surface which could be cast in plaster, giving a permanent surface for study. The plaster cast method has already shown many features of lug action before unconsidered and it is believed that it offers possibilities of solving many important questions of lug design, which to date have been questions of uncertain speculation by tractor designers.

NOTE: The authors wish to acknowledge the very valuable assistance of the Office of Experiment Stations of the U. S. Department of Agriculture through R. W. Trullinger, specialist in rural engineering, in organizing the attack on the lug problem, progress in the development of which is set forth in the foregoing article.

References

(1) A. T. Goldbeck, Proc. A. S. T. M. 1917 (The Distribution of Pressure Through Earth Fills.)
(2) B. McCollum and O. S. Peeters (A New Electric Telemeter. Technological and Bureau Standards No. 247, 1924)
(3) A. T. Goldbeck and M. J. Bussard (The Supporting Value of Soil as Influenced by the Bearing Area. Public Roads Vol. No. 11, Jan. 1925)
(4) Randolph, J. W., and Nichols, M. L. (Paper in course of preparation.)
(5) Bie, E. Proc. Brooklyn Eng. Club No. 190

Silage Cutting Costs

There has been considerable argument on the comparative costs of cutting silage in the field and at the silo. It is a case of where there is much to be said on both sides; each method has its advantages. It would be very much worth while if several agricultural experiment stations made a careful study of this matter this season in order to get the facts. Perhaps some of them have already. Anyway let's get the facts.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in rural engineering, Office of Experiment Stations, U. S. Department of Agriculture

Home Sewage Disposal, W. A. Hardenbergh. (Philadelphia and London: J. B. Lippincott Co., 1924, pp. VII—274, figs. 82.) This handbook has been prepared for use by health officers in the field and to furnish data for engineers interested in sewage disposal for single homes, small communities, and institutions. An insight into the purpose and problems underlying sewage disposal in its relation to health work is also given.

It is divided into four parts. Part 1 contains chapters on the need for and results of sanitation, the principles of sanitation, chemical and bacteriological processes during sewage treatment, and selecting the methods of disposal; part 2 on sewage disposal for unsewered sections, contains chapters on the pit privy, the double compartment concrete vault, the box and can privy, the septic closet, the chemical closet, and disposal of excreta; part 3, on the treatment of sewage, contains chapters on the small septic tank, small Imhoff tanks, other means of treatment, and secondary treatment of sewage; and part 4, dealing with problems in field sanitation, contains chapters on construction details, soil and water pollution, and flies and the filth-borne diseases. An appendix on ordinances and specifications is included.

Results of Tests to Determine Heat Conductivity of Various Materials, C. H. Herter, (Refrigeration Engineers, New York, 10 (1924), No. 7. pp. 256-280, fig. 1.) A large amount of tabular data is presented containing numerical values for the rate of heat flow through most of the materials an engineer has to deal with. An attempt has been made to list the various materials approximately in the order of their power to resist heat flow.

It is noted that some of the loose insulating materials show as low a heat conductivity as does air alone. This is attributed to the fact that in a filled space the diminished convection and radiation offset the conduction proceeding through the fibers of the insulator. The packing of an air space with insulating material is, therefore, of particular advantage.

In the absence of a series of tests of each material at various densities it is considered hardly possible to state just which density or rate of packing will result in the least heat conduction. It is noted in this connection that lower heat conduction was obtained with eiderdown at 6.8 pounds per cubic foot than with 4.92 pounds because in the latter case there was a better chance for convection. Similar results were obtained with absorbent cotton. The heat conduction of dry granulated cork seemed to depend more upon the state of division and absence of foreign substances than on the greater density, some grades at 3 pounds per cubic foot showing up as favorably as grades three times as dense.

It is further pointed out that all so-called insulators are more effective per degree difference at low than at high temperatures, that property being due to radiation in the minute air cells and to included moisture. However, there is no uniform behavior in this respect in metals, the conductivity increasing in one metal and decreasing in another.

Flood Flow Characteristics, C. S. Jarvis. (American Society Civil Engineers Proceedings, 50 (1924), No. 10, pp. 1545-1581, pl. 1. figs. 8.) The characteristics of flood flow that may have either general or special application and, therefore, must be considered in any preliminary studies for drainage are briefly stated, not by way of defining probable flood limits for individual cases but of indicating methods of deduction that must be followed. Available data which seemed reliable and valuable to the author are listed and platted to give a visual representation of the range of discharge per square mile for maximum recorded floods.

A method of approach is explained by which problems in several central and western districts have been solved satisfactorily, both as to flood prevention and property protection. In addition a variety of representative basic and auxiliary data are presented in convenient form.

Guide to Agricultural Machinery, G. Kuhne. (Leitfaden der Landwirtschaftlichen Maschinenkunde, Berlin: Deut. Landw. Gesell., 1923, 2. rev. ed., pp. VI+122, figs. 237.) This is the second, revised edition of this publication which describes the materials used in the manufacture of farm machinery, some of the more important generally applicable mechanical details, and leading examples of the different main types of machines.

The Motor Truck—Applied Mechanics for Owners and Drivers, E. E. La Schum and H. E. Bardwell. (New York: U. P. C. Book Co., Inc., 1924, pp. XIII + 325, figs. 67.) This is a handbook of information for motor-truck operators. It contains chapters on the field of the motor truck, the power plant, carburetors, electrical equipment, radiators, lubrication, fuel and heat, the chassis, running gear, performance, and record of performance and maintenance.

The "Artesian Well" as a Potential Source of Danger, C. N. and F. D. Leach. (American Journal Public Health, Albany, N. Y. 14 (1924), No. 10 pp. 827-831, figs. 5.) In a contribution from the International Health Board of Manila, P. I., studies are reported of forty-six artesian wells in the neighborhood of Manila.

The results showed that only 26 per cent of these wells are furnishing a potable water of good quality. Three of the negative wells, however, showed a high bacterial count. There is considered to be a strong possibility that the water from this small percentage of clean wells is contaminated by handling before reaching the consumer.

Of the wells examined, 45.6 per cent gave a positive dye test for leaky casings. Water for priming was obtained from nearby ditches. Eight of the ten priming wells gave a positive presumptive test. Positive bacteriological tests were obtained from 71.7 per cent of the forty-six wells examined.

Aeration Studies on Creamery Waste Purification, M. Levine, L. Soppeland, and G. W. Burke. (Iowa Engineering Station Bulletin 68 (1923), pp. 39.) Studies on the principles involved in the purification of dairy wastes are reported.

The results showed that a creamery waste differs markedly from ordinary sewage in many respects, but particularly in that it contains the carbohydrate lactose which rapidly undergoes acid fermentation, thereby rendering the waste extremely refractory to septic tank treatment. It was found that the acid producing constituents can be eliminated by direct oxidation. Four hours' aeration of 2 or even 3 per cent skim milk with activated sludge was sufficient to yield effluents which would not become appreciably acid on storage under anaerobic conditions, and which would, therefore, probably not be objectionable for admixture with sewage in septic tanks. An activated sludge was developed in about two weeks from 2 per cent skim milk.

Aeration of 2 per cent skim milk for from sixteen to twenty-three hours in bottles or in barrels, with 20 per cent activated sludge and from 50 to 60 cubic feet of air per gallon, effected marked reductions in turbidity, acidity, total solids, organic nitrogen, and particularly in oxygen consumed and oxygen demand. Reductions of from 95 to 98 per cent in the oxygen requirements were generally obtained.

Activated sludge treatment was more effective with 2 per cent buttermilk than with skim milk.

With separately, partially aerated sludge, employing an aeration period of six hours and 15.6 cubic feet of air per gallon, there was an average reduction of 43.9 per cent solids, 77.7 per cent organic nitrogen, and 76 per cent oxygen consumed and oxygen demand. Reducing the air supply to 11.4 cubic feet per gallon and increasing the aeration period to 12 hours resulted in about 20 per cent greater reductions.

Elimination of 95 per cent of the oxygen requiring constituents from 2 per cent skim milk or buttermilk was not sufficient to yield stable effluents. It is thought that possibly better distribution of air, together with mechanical agitation, may give more stable effluents.

These results are taken to indicate that the employment of activated sludge with a view to yielding stable effluents may not be economically practical for a small plant. However, it is concluded that the possibilities of utilizing activated sludge and particularly trickling filters as preliminary processes for treatment of creamery wastes warrant investigation.

Modern Farm Machinery, D. N. McHardy, (London: Methuen & Co., Ltd., 1924, pp. XVIII+235, pls. 3, figs. 147.) This book deals mainly with mechanical aids to agricultural production and to a certain extent with transporting machinery. It contains chapters on mechanical principles employed in farm machinery, materials and methods used in the construction of farm machinery, the plow, operation of the plow, special purpose plows, drainage machinery, cultivators, harrows, and rollers; rotary tillage; seeding machinery; artificial manure distributors; root growing machinery, the grass mower; hay harvesting machinery; the reaper and binder; stationary motors for farm work; barn machinery; the cream separator; the threshing machine; the ensilage cutter; elevating and conveying machinery; pumps and spraying machinery; farm transport; electricity on the farm; and the farm workshop.

Progress in Rural Service Study, I, II, A. M. Perry. (Electrical World, New York 84 (1924), Nos. 24, pp. 1253-1257, figs. 5: 25, pp. 1297-1301, figs. 6.) These two articles deal with progress in the work undertaken on the application of electricity to agriculture by several state colleges and experiment stations. Special attention is drawn to the work undertaken by the Minnesota station, and some of the details are outlined.

Colter and Plow Point [trans. title]' M Ringelmann. (Journal Agricultural Practices, Paris, n. ser., 42 (1924), No. 43, pp. 337-339, figs. 6.) A brief analysis is given of the influence of the location of a knife colter, either in front of or behind the plow point, on draft. An actual test showed that the draft was 3 per cent greater where the colter was placed in advance of the plow point, indicating apparently that the location of the knife colter has a greater relative influence on the draft than that of the plow point with respect to the colter.

The Farmer's Shop Book, L. M. Roehl. (Milwaukee: Bruce Publishing Company, 1923, pp. 432, figs. 131.) This book has been prepared on the basis of the farm shop work taught in the New York State College of Agriculture, and presents a very detailed description of the many features of this work, including a large number of both diagrammatic and photographic illustrations. It contains chapters on shop, household, field, stock, poultry, barn, orchard, crop, bee and bird, and playground appliances; farm buildings; hinges, locks, and builders' hardware, window repairing; bolts and rivets; drills, taps, and dies; vise work; metal work; attaching farm tool handles; saw filing and tool sharpening; rope work and tackle blocks; harness repairing and belt lacing; painting; and agricultural drawing.

Further Data on Infiltration of Air Through Building Openings, C. C. Schrader. (Journal American Society Heating and Ventilating Engineers, New York 31 (1925), No. 1, pp. 1-4, figs. 2.) The results of further tests covering the leakage around doors and double casement windows are reported. The data presented serve to emphasize the fact that the application of weather stripping tends to minimize the individual or combined effects of size of cracks around openings, wind velocity, and outside temperature on the heating requirements.

The Chemistry and Physics of Clays and Other Ceramic Materials, A. B. Searle. (New York: Van Nostrand Co., 1924, pp. XIII + 695, figs. 52.) This book, while prepared primarily from the ceramic standpoint, contains a large amount of information relating to the chemistry and physics of clays, which should be of value in a study of soils and soil dynamics.

Calculation of the Coefficient of Permeability of Clay From the Hydrodynamic Pressure Phenomena [trans. title], K. v. Terzaghi. (Sitzber. Akad. Wiss. Wien, Math. Naturw. Kl., 132 (1923), IIa. No. 3-4, pp. 125-138, figs. 4; abs. in Sci. Abs., Sect. A-Phys., 27 (1924), No. 322, pp. 853, 854.) Studies are reported in which it was found that in clay with a porosity number less than 2 and a coefficient of permeability greater than 0.06 centimeters per year, there was no appreciable variation from the law of Darcy.

In an investigation to determine the coefficient of permeability of loam and of clay in the viscous-plastic and in the semisolid form, the direct method of measurement failed because the coefficient of permeability of the soils in this form was very small as compared with a coefficient of 0.06 centimeters per year. A method was, therefore, developed to avoid the errors of the direct method, which consisted in the observation of the time change of the pressure phenomena in clay. The hydrodynamic pressure phenomena is considered to be the delay which is caused in clay in the pressure due to the resistance to the outflow of squeezed out water. It is stated that the permeability coefficient can be calculated from the time variation of the equalization of pressure as long as all other important factors are known.

With the help of diagrams, the case of a block of loam or clay of height h contained in a vessel which will prevent spreading is considered. As the pressure is increased the porosity number and the coefficient of permeability decrease, and a definite amount of water is squeezed out of the clay. The unit of volume is taken as a prism of unit sectional area. The length of the prism in the direction of the pressure is variable, the reduced thickness of the layer is the thickness which the layer would have if the porosity number were O, and the coefficient of permeability denotes the velocity of flow of the water through a layer of clay of the real thickness when the difference of pressure height is one centimeter. The differential equation for the flow is exactly the same as that for the nonstationary propagation of heat in an isotropic medium. The solution of the equation is given, and the results for special cases are platted. It is concluded that Darcy's law holds for the flow of water through loam in a semisolid form.

Removal of Capillary Moisture in Highway Subgrades, C. M. Upham and H. F. Janda. (Engineering News-Record, New York 93 (1924), No. 23, pp. 912, 913, figs. 3.) Studies are reported with several soils such as clay, sand-clay, top soil, etc., which showed that draintile are of no direct value in removing or preventing the rise of purely capillary moisture, and that the percentage of capillary moisture is reduced as the elevation of the subgrade above the water table is increased.

It was further found that a layer of coarse noncapillary material is an effective agent in preventing the rise of capillary moisture, some materials being more effective than others. Sand seemed to be the most effective agent in preventing such capillary action.

Storage Batteries, G. W. Vinal, (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1924, pp. VIII+402, figs. 156.) This is a general treatise on the physics and chemistry of secondary batteries and their engineering applications, and is based on the operations of the U. S. Bureau of Standards along this line. It contains chapters on materials and methods of construction; the electrolyte; theory of reactions, energy transformations, and voltage; capacity; operation; resistance; efficiency; testing storage batteries; and present-day uses for storage batteries.

Strength of Materials, W. E. Wines. (New York and London; McGraw-Hill Book Co., Inc., 1923, pp. XX+241, figs. 103.) This is one of the Engineering Education Series, prepared in the extension division of the University of Wisconsin. The subject matter has been selected to meet the requirements of both machine and structural designers and to form the foundation for more advanced study along these lines. Chapters are included on fundamental properties of materials and their measurement; materials; simple stresses; elastic properties of materials; thin-walled cylinders, pipes, riveted joints; center of gravity and moment of inertia; beams-reactions, shear, bending moments; beam stresses and deflections; columns; and torsion.

Mechanical Refrigeration, H. Williams. (London: Isaac Pitman & Sons, Ltd., 1924, new and enlarged edition, pp. X—501, pls. 6, figs. 16.) This is a practical introduction to the study of cold storage, ice making, and other purposes to which refrigeration is applied. It contains chapters on general principles; the laws of fluids, heat, liquids, gases, and vapors; thermodynamics; historical data, the properties of ammonia, carbonic anhydride, and other refrigerants; types of machines; the refrigerating plant; auxiliary plant, insulation; brine; ice making; cold storage; articles in cold storage; other applications; and the design of abattoirs, and freezing and meat packing works.

Permeability Tests on Broken Stone Concrete, M. O. Withey and C. A. Wiepking. (Wisconsin University Bulletin, Engineering Service, Madison 9 (1923), No. 2, pp. 55, figs. 15.) Tests of the influence of age, thickness, richness of mix, grading of aggregate, time of mixing, consistency, curing treatment, and direction of flow on the water-tightness of broken stone concrete are reported.

None of the concretes tested were absolutely water-tight if continuous flow into the specimen is considered proof of permeability. The specimens of rich mixes when submitted to proper curing conditions were so impervious that no leakage was apparent at the free surface. Such concretes are considered water-tight for ordinary purposes.

The cement content of a given mix appeared to be the most important factor in determining the degree of impermeability. Other factors remaining constant, the water-tightness of concrete made with well graded aggregate increased with the proportion of cement in the mix. This was very marked as the cement content was raised until the ratio of cement to aggregate by weight was 0.15. A further increase in cement content was attended by a relatively small increase in water-tightness. For the broken stone concretes a ratio of cement to aggregate by weight of 0.17 or more gave a water-tight mix, whereas a cement-aggregate ratio of 0.14 was sufficient for gravel concrete mixes. Mixes containing high proportions of cement were much less affected by variations in consistency, time of mixing, and grading of aggregate than lean mixes.

The ratio of the volume of cement to the volume of air plus water voids is considered to be a valuable measure of both the strength and water-tightness of concrete. The strength increased nearly in direct proportion to the cement-voids ratio for the mixes tested. Water tightness in the mixes of broken stone concrete was obtained when the cement-voids ratio was 0.55 or above. A ratio of 0.45 gave similar results for gravel concrete.

The water-tightness of mixes containing less than 14 per cent of cement to total dry materials by weight was much affected by variations in consistency, curing conditions, placement, and grading of the aggregate. It was also affected to a lesser extent by variations in the time of mixing and by the moisture content of the fine aggregate. Lean concretes made of angular broken stone were more sensitive to the effects of these variables than similar mixes containing round pebbles. Maximum water-tightness was found to obtain for a limited range of the water-cement ratio. This range was much wider for the rich mixes than for the lean ones.

A plastic consistency giving a slump of from 1 to 3 inches when tested in a 6 by 12-inch cylinder appeared to be best suited to produce an impervious concrete with a minimum of cement. The use of excessive amounts of water greatly increased the permeability of lean mixes. It was necessary that concrete be cured in a moist atmosphere or under water to secure a high degree of imperviousness. Lean mixes or thin sections required longer wet curing periods than rich mixes or thick sections. The effect of dry curing appeared to be much more detrimental to water-tightness than to compressive strength. It appeared that lean mixes made with damp sand required a somewhat longer mixing period than when made with dry sand.

These results are taken to indicate that for making water-tight concrete well graded gravel of good quality is superior to broken stone of like quality and grading.

Engineering Progress in General-Purpose Farm-Tractor Development. O. B. Zimmerman. (Journal Society of Automotive Engineers, New York 16 (1925), No. 1, pp. 47-52, figs. 10).Typical, early, and recent developments of the general-purpose farm tractor are reviewed. It is stated that the original steam power equipment was intended to serve as a portable belt power unit, and was used almost entirely to operate threshing machines, many men and horses and various supplies being needed in addition.

Internal-combustion engines were utilized in farm tractors about twenty years ago for plowing and to supply belt power. Other operations such as disking, harrowing, and hauling loads on highways were attempted, but owing to the great weight of the equipment they gave little satisfaction. Engineering effort was directed about ten years ago toward reducing the weight of tractors suitable for belt power and drawbar work, also to the improvement of equipment for use in connection with tractors. Power take-off whereby power from the tractor power plant is transmitted directly to the implement resulted in greater mechanical simplicity and reduced the weight.

Major requirements in general-purpose tractor design are enumerated as adjustable ground clearance, proper width of wheels and of wheel spacing, and a short turning radius.

In summarizing the situation it is stated that what originally started, roughly speaking, as a 20,000 pound gasoline power unit now weighs about 3,300 pounds and has a speed of three miles per hour or more, as compared with an original speed of less than two miles per hour.

News Section

Meeting to Organize Southwest Section of Society

THE first meeting of agricultural engineers held in the Southwest and a meeting primarily called for the purpose of organizing the Southwest Section of the American Society of Agricultural Engineers was called at the A. and M. College of Texas on Friday, May 15. The attendance was considered extremely satisfactory as there were about twenty-five in number, with the agricultural engineering population of that section of the country being extremely sparse.

The forenoon of Friday was taken up with registration, getting acquainted, and an inspection of the College.

An exceptionally interesting program had been arranged by the program committee and was carried out practically as planned. The first paper was presented by R. G. Hemphill of San Antonio, Texas, and dealt with irrigation seepage losses in the Rio Grande valley. Following a brief discussion of this paper, A. D. Jackson, publicity director of the Texas Agricultural Experiment Station, gave an interesting review of the flood control work in Texas, and presented his ideas on some of the problems confronting the engineer in Texas with flood control. The third and final paper on Friday was a discussion of land terracing in Texas by M. R. Bentley, extension agricultural engineer. Following this paper the meeting adjourned until Saturday morning, and the entire group witnessed the Southwestern University-A. and M. College baseball game as guests of the Athletic Department.

On Friday night a banquet was given in the college mess hall at which talks were made by Dean E. J. Kyle, Dean F. C. Bolton and A. B. Conner of the Experiment Station.

The meeting opened Saturday morning with a discussion of farm mechanics in vocational agricultural schools by J. J. Brown, assistant director of vocational agriculture in Texas. Mr. Brown's talk was supplemented by a discussion by S. S. Graham, agricultural engineer at Sam Houston's Teacher's College. Other papers presented were as follows:

"Some Factors Influencing the Scouring of Plows", by W. L. Ledbetter, Southern Plow Company, with discussion by H. P. Smith, associate professor of agricultural engineering, A. and M. College of Texas; "Sanitary Milk Supply", by Leslie C. Frank, sanitary engineer, U. S. Public Health Service, with discussion by V. M. Ehlers, state sanitary engineer, and Dr. Sappington, Texas State Board of Health; and "Time and Labor Saving Devices for the Home", by Mildred Horton, extension service, A. and M. College of Texas.

The meeting was concluded Saturday noon with a brief business session at which it was definitely decided to petition the Council of the Society for the organization of a Southwest Section. A constitution and by-laws have been drafted and will be submitted to all interested at a very early date. This will be followed by the selection of officers and committee appointments.

Pacific Coast Section Meeting At Los Angeles

THE Pacific Coast Section of the American Society of Agricultural Engineers held its annual meeting at the Hotel Clark, Los Angeles, May 29. A complete report of the meeting is not available as this issue of the Journal goes to press.

At the business session the following officers were elected for the ensuing year: Chairman, Frank Adams, professor of irrigation investigations and practice, University of California, Davis; vice-chairman, Max E. Cook, architectural engineer, California Redwood Association, Los Angeles; secretary-treasurer, L. J. Fletcher, professor of agricultural engineering, University of California, Davis; and two directors, F. J. Southerland, sales engineer, Pacific Gas and Electric Company, San Francisco, and W. J. Gilmore, professor of agricultural engineering, Oregon Agricultural College, Corvallis.

There were twenty-five in attendance at the meeting. Max E. Cook presented an illustrated paper entitled "Farm Structures—Maximum Results at Minimum Cost." David Weeks, of the University of California, gave a very interesting talk on his recent economic investigations on state and government projects in California and Nevada. B. D. Moses, of the University of California, gave a very interesting report on work of the California Committee on the Relation of Electricity to Agriculture.

College Division Election

THE election of members of the Advisory Committee of the College Division of the American Society of Agricultural Engineers resulted in the reelection of J. B. Davidson, professor of agricultural engineering, Iowa State College, and the election of H. H. Musselman, professor of agricultural engineering, Michigan State College.

The other two elective members of the Advisory Committee are L. J. Fletcher, professor of agricultural engineering, University of California, and R. U. Blasingame, professor of farm machinery, Pennsylvania State College.

This group consists of members of the student branch of the American Society of Agricultural Engineers at Iowa State College and members of the agricultural-engineering faculty

Electrical Training for Agricultural Engineering

OF special interest to the engineering profession is the resolution which was adopted at the annual convention of the middle-west division of the National Electric Light Association which was held at Omaha, Nebraska, in May, relative to giving an opportunity to young agricultural engineers for training in electrical engineering. The resolution which was passed at the convention is as follows:

"WHEREAS: There exists a need for agricultural engineers, who have had training in electrical engineering, and whereas the supply of men trained as agricultural engineers, and even more so, agricultural engineers with electrical training is very limited.

"BE IT RESOLVED: First, that the universities and colleges now giving training to agricultural engineers be encouraged to give such men facilities for training in electrical engineering and that facilities for research in the application of electricity to agriculture be provided.

"Second, that the electric light and power companies and the manufacturers of electric equipment give the men, who are now studying agricultural engineering an opportunity to study electrical-agricultural problems by offering summer employment to such men; and

"BE IT FURTHER RESOLVED, That copies of the above resolutions be sent to Dr. W. M. Jardine, Secretary of Agriculture; to the presidents of the agricultural colleges; deans of the departments of agriculture in the universities; to the chief of the division of agricultural engineering in all colleges where work in agricultural engineering is now offered and to all of the state or district directors of committees on public utilities information; that this resolution be printed in the N. E. L. A. Bulletin, in the C. R. E. A. Bulletin, and be given further distribution as may seem advisable."

Personal

K. J. T. Ekblaw has resigned as agricultural engineer for the Portland Cement Association to accept a position as sales engineer of Scotts Business Analysts, 153 North Michigan Avenue, Chicago.

L. G. Heimpel, head of the department of agricultural engineering at MacDonald College, Quebec, is co-author with his associate, F. D. Norris of the same institution, of Bulletin No. 89, "Tile Drainage of Farm Lands," issued by the Department of Agriculture of the Province of Quebec, Canada. The bulletin is a very creditable piece of work and should be in the hands of all those who are interested in tile drainage.

B. P. Hess has resigned as county extension agent at Georgetown, Ohio, to accept the position of special investigator with the Ohio Committee on the Relation of Electricity to Agriculture, of which **P. B. Potter,** of the Ohio State University, is executive secretary. The work of the committee will start with a survey on what constitutes an electrically equipped farm, to be followed with the establishing of an experimental rural line.

Stanley F. Morse, consulting agricultural engineer, has added airplane dusting to his agricultural service. Mr. Morse, in connection with his brother, Alan L. Morse, an aeronautical engineer who has been engaged in the development of balloon dusting apparatus for several years, are equipped with improved apparatus and are booking contracts for dusting in New England and the southern cotton districts.

J. D. Parsons has resigned as assistant professor of agricultural engineering at the University of Nebraska to become associated with the sales department of the Butler Manufacturing Company, Kansas City, Missouri.

W. W. Weir, assistant professor of soil technology, University of California, is author of Bulletin No. 382, just issued by that institution and entitled "Pumping for Drainage in the San Joaquin Valley, California."

New A. S. A. E. Members

George Waverly Cravens, vice-president, Climax Engineering Company, Clinton, Iowa.

Albert O. Kay, associate drainage engineer, division of agricultural engineering, U. S. Department of Agriculture, Cocoa, Florida.

Orla Glen Miller, lubrication engineer, Standard Oil Company, 910 S. Michigan Avenue, Chicago, Illinois.

Frederick Jewell Southerland, sales engineer, Pacific Gas & Electric Company, 245 Market Street, San Francisco, California.

Ray T. Wagner, commercial engineer, General Electric Company, Schenectady, New York.

TRANSFER OF GRADE

Ralph W. Baird, 152 Campus Avenue, Ames Iowa. (From Student to Junior Member.)

Luther H. Koontz, drainage engineer, New Carlisle, Ohio. (From Student to Associate Member.)

Erwin K. Young, drainage engineer, Dresden Road, Zanesville, Ohio. (From Student to Associate Member.)

Applicants for Membership

The following is a list of applicants for membership received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Primo R. Carreon, graduate assistant in rural engineering, Department of Rural Engineering, Los Banos College, Laguna, Philippine Islands.

Charles H. B. Chapin, secretary, Empire State Gas & Electric Association, 5618 Grand Central Terminal, New York City.

Charles Harvey Churchill, Jr., director of rural activities, Adirondack Power & Light Corporation, 511 State Street, Schenectady, New York.

Arthur T. Upson, lumber standards advisor, National Lumber Manufacturers Association, 402 Transportation Building, Washington, D. C.

A. S. A. E. Employment Service

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of Agricultural Engineering. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Nonmembers as well as members, are privileged to use the "Positions Available" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

Men Available

AGRICULTURAL ENGINEER open for position as sales engineer, salesman, advertising writer, or agricultural propagandist. Past experience with large agricultural firms. MA-124.

AGRICULTURAL ENGINEER, 1925 graduate of Kansas State Agricultural College, with farm experience, would like permanent employment at once, preferably with a farm-machinery manufacturer. MA-126.

AGRICULTURAL ENGINEER, graduate of Iowa State College, E. E. 1903, A. E. 1910, desires to make change. Ten years experience in field and factory on tractors, trucks, and farm machinery. Five years teaching experience in agricultural engineering and farm mechanics. Instructional work along agricultural engineering lines preferred. MA-126.

Positions Open

SALES ENGINEERS (two) wanted by Middle West manufacturing company. Applicant should have designing ability and a general knowledge of tractor and agricultural implement practice. The men we want are only those who can work their way into the confidence of customers through designing and engineering service. Actual sales experience in line with above qualifications is desirable. Write, giving name, age, and list of qualifications; also salary expected. PO-201.

Keeping the

The barn is a pretty important building to our agricultural industry. We can do without some paint on our front porch, but unless the nation's barns are dry, our stock, our implements and much of last year's harvest may be lost to us forever.

The electric light and power industry has its barns too (although they call them power houses); its live stock and its implements are the generating and transmission equipment from which electric service comes.

The cost of furnishing electric service includes not only the money needed

NATIONAL ELECTRIC

29 West 39th Street